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ENGRAVING ELEMENT

The invention is in the field of electronic reproduction technology and is directed to an engraving element for engraving printing forms for rotogravure as well as to a damping mechanism for an engraving element.

In an electronic engraving machine, an engraving element with an engraving stylus as cutting tool moves along a rotating printing cylinder in axial direction. The engraving stylus controlled by an engraving control signal cuts a sequence of cups arranged in a rotogravure raster into the generated surface of the printing cylinder. The engraving control signal is formed by superimposition of a periodic raster signal with image signal values that represent the hues to be reproduced between "black" and "white". Whereas the raster signal effects a vibrating lifting motion of the engraving stylus for generating the rotogravure raster, the image signal values control the cutting depths of the engraved cups in conformity with the hues to be reproduced.

DE-A-23 36 089 discloses an engraving element with an electromagnetic drive element for the engraving stylus. The electromagnetic drive element is composed of a stationary electromagnet charged with the engraving control signal in whose air gap the armature of a rotatory system moves. The rotatory system is composed of a shaft, the armature, a bearing for the shaft and of a damping mechanism. One shaft end merges into a stationarily clamp, resilient torsion rod, whereas the other shaft end carries a lever to which the engraving stylus is attached. An electrical torque is exerted on the armature of the shaft by the magnetic field generated in the electromagnet, this electrical torque being opposed by the mechanical torque of the torsion rod. The electrical torque turns the shaft around its longitudinal axis by a rotational angle proportional to the respective image signal value, turning this from a quiescent position, and the torsion rod guides the shaft back into the quiescent position.

Due to the rotational movement of the shaft around the longitudinal axis, the engraving stylus executes a lifting motion directed in the direction onto the

generated surface of the printing cylinder, this respectively defining the penetration depth of the engraving stylus into the printing cylinder.

The damping mechanism serves the purpose of defined damping of rotational oscillations and transverse oscillations of the rotatory system and, thus, for damping the movement of the engraving stylus.

Given, in particular, sudden changes in the image signal values at steep density transitions (contours), the engraving stylus can exhibit a faulty activation and deactivation behavior that is essentially dependent on the degree of damping achieved in the damping mechanism. The consequence of a faulty activation behavior of the engraving stylus is engraving errors on the printing cylinder or, respectively, disturbing changes in hue in the print.

Given inadequate damping of the rotatory system, disturbing multiple contours arise at density discontinuities due to over-shooting of the engraving stylus. Given too great a damping of the rotatory system, the engraving stylus cannot follow fast enough at steep density transitions, and the rated engraving depth is only achieved or left at a distance following the density discontinuity, as a result whereof steep density discontinuities are reproduced unsharp.

Moreover, a high temperature and long-term stability of the degree of attenuation are required.

The quality in the engraving of printing forms is thus influenced substantially by the degree of damping of the engraving element.

In a first exemplary embodiment, the damping mechanism disclosed by DE-A-23 36 089 is composed of a damping element connected to the shaft of the engraving element that immerses into a stationary damping chamber filled with a damping grease as damping agent. The damping element is fashioned as a circular damping disk or has at least one damping wing. A damping grease loses its damping properties over time due to the mechanical stressing and thus does not exhibit the required long-term stability.

In a second exemplary embodiment, the damping mechanism disclosed by DE-A-23 36 089 comprises two or more identical damping elements axially symmetrically at the circumference and stationarily connected at the outside to a seat,

these damping elements residing under pre-stress in radial direction. The damping elements are composed of an elastic-plastic synthetic, for example of a fluor-elastomer. The degree of attenuation that can be achieved at the moment with an elastic-plastic synthetic is dependent on the respectively preceding shaping. This "memory" effect disadvantageously leads to the fact that the engraving stylus achieves and in turn departs the rated engraving depth only with a disturbing delay.

In order to achieve a higher engraving speed, efforts have been undertaken to increase the engraving frequency, i.e. the frequency of the raster signal. A higher engraving frequency, however, leads to an increased production of heat in the engraving element. The employment of damping elements composed of an elastic-plastic synthetic has the further disadvantage that this does not eliminate the heat fast enough, this potentially leading to a modification for the degree of damping and, thus, to disturbing engraving errors.

US-4,357,633 recites another electro-mechanical engraving element having a damping mechanism. The damping mechanism is composed of a circular damping disk connected to the shaft and of a stationary, annular bearing disk between which damping elements composed of an elastic, non-compressible material are arranged.

US-4,123,675 discloses a damping mechanism for a stepping motor drive, whereby a magnetic disk with high inertia floats in a housing filled with a ferro-fluid. The housing is rigidly connected to the shaft of the stepping motor, i.e. it turns together with the stepping motor, and the friction between the inside housing wall and the inertial disk effects the damping.

The invention is based on the object of improving an engraving element of an electronic engraving machine for engraving printing forms as well as a damping mechanism for an engraving element such that the movement of the engraving stylus of the engraving element is optimally damped in order to achieve a high engraving quality.

This object is achieved by the features of claim 1 with respect to the engraving element and is achieved by the features of claim 25 with respect to the damping mechanism.

Advantageous improvements and developments are recited in the subclaims.

The invention is explained in greater detail below with reference to Figs. 1 5 through 9.

Shown are:

Fig. 1 the schematic structure of an engraving element having a damping mechanism in a perspective view;

Fig. 2 an exemplary embodiment of a rotational-symmetrical damping mechanism having a circular or circular sector-shaped damping disk, shown in section;

Fig. 3 an exemplary embodiment of a non-rotational symmetrical damping mechanism having a circular segment-shaped damping disk, shown in section;

Fig. 4 an exemplary embodiment of a rotational-symmetrical damping mechanism having two circular or circular sector-shaped damping disks, shown in section;

Fig. 5 an exemplary embodiment of a non-rotational-symmetrical damping mechanism having two circular segment-shaped damping disks, shown in section;

Fig. 6 a development of a rotational-symmetrical damping mechanism having an integrated spoke bearing, shown in section;

Fig. 7 a development of a non-rotational-symmetrical damping mechanism having an integrated spoke bearing, shown in section;

Fig. 8 a perspective illustration of a rotational-symmetrically fashioned spoke bearing; and

Fig. 9 a perspective illustration of a non-rotational-symmetrically fashioned spoke bearing.

Fig. 1 shows a perspective illustration of the structure of an engraving element that is fundamentally composed of a drive system - of an electromagnetic drive system in the illustrated example - and of a rotatory system.

The electromagnetic drive element is composed of a stationary electromagnet (1) having two u-shaped plate packets (2) lying opposite one another and two air gaps (3) lying between the legs of the plate packets (2). A coil (5) - which is shown from only coil side - is located in the recesses (4) of the plate packets (2) of the electromagnet (1). The coil (5) has an engraving control signal flowing through it.

The rotatory system is composed of a shaft (6), of an armature (7) secured to the shaft (6), as well as of a damping mechanism (8) and a spoke bearing (9) for the shaft (6). The armature (7) is movable in the air gaps (3) of the electromagnet (1). One shaft end merges into a resilient torsion bar (10) that is clamped in a stationary bearing (11, 12). The other shaft end (13) carries a lever (14) to which the engraving stylus (15) is attached. The damping mechanism (8) and the spoke bearing (9) are arranged between the armature (7) and the lever (14) with the engraving stylus (15). As a result of the magnetic field generated in the air gaps (2) [sic] of the electromagnet (1), an electrical torque is exerted on the armature (7) of the shaft (6), this electrical torque being opposed by the mechanical torque of the torsion bar (10). The electrical torque turns the shaft (6) around its longitudinal axis with a rotational angle proportional to the respective engraving control signal value, turning this out of a quiescent position, and the torsion bar (10) returns the shaft (6) into the quiescent position. As a result of the rotatory motion of the shaft (6), the engraving stylus (15) implements a stroke directed in the direction onto the generated surface of a printing cylinder (not shown) that defines the penetration depth of the engraving stylus (15) into the printing cylinder. When engraving, the rotatory system executes an oscillation motion dependent on the frequency of the raster signal by a very small rotational angle of, for example, a maximum of $\pm 0.5°$, this corresponding to a maximum stroke of approximately 250 μm of the engraving stylus (15).

The drive system for the engraving stylus (15) can also be fashioned as a solid-state actuator element that, for example, can be formed for a piezoelectric or of a magnetostrictive material.

Fig. 2 shows an exemplary embodiment of a rotational-symmetrical damping mechanism (8) having a circular or circular sector-shaped damping disk (17).

Fig. 2a shows a sectional view of the damping mechanism (8) in axial direction of the shaft (6). The damping mechanism (8) is essentially composed of a damping disk (17) that is connected to the shaft (6) and expands perpendicular to the shaft (6) and is further composed of a stationary damping chamber (18). The damping disk (17) is fashioned as at least one damping wing (Fig. 2c) rotational-symmetrically

relative to the shaft (6) either circularly (Fig. 2b) or circular sector-shaped. The stationary damping chamber (18) is fashioned as a rotational-symmetrical hollow cylinder around the shaft (6) having a u-shaped cross-section into whose interior facing toward the shaft (6) the damping disk (17) immerses. When the damping disk (17) is fashioned as at least one damping wing, the damping chamber (18) can be composed of hollow cylinder segments that respectively extend at least over a damping wing (17). The stationary damping chamber (18) is composed of a disk-shaped base plate (20), of a disk-shaped cover plate (21) and of a spacer ring (22) lying between base plate (20) and cover plate (21). The base plate (20) and the cover plate (21) comprise through openings (23, 24) for the shaft (6). Base plate (20), cover plate (21) and spacer ring (22) are arranged such relative to one another and connected to one another with, for example, screws (25) that they form the interior of the damping chamber (18). The spacer ring (22) is dimensioned that a defined damping gap (26) for the acceptance of a damping fluid arises between base plate (20), cover plate (21) and spacer ring (22) on the one hand and the damping surfaces of the damping disk (17) on the other hand.

The diameter of the through opening (24) in the cover plate (21) is selected such that an additional damping gap (26') for the damping fluid is formed between the inside surface that faces toward the shaft (6) and the generated surface of the shaft (6). The damping disk (17) can be provided with through holes (27) proceeding in axial direction of the shaft (6). The through holes (27) form connecting channels to the damping gaps (26) above and below the damping disk (17) and advantageously serve for compensating the damping fluid and as a reservoir for the damping fluid. Over and above this, the through holes (27) reduce axial vibrations of the damping disk (17).

A ferro-fluidic fluid is preferably employed as damping fluid in the damping chamber (18). A ferro-fluidic fluid is a colloidal solution of magnetic particles in an oil that can be magnetized. A ferro-fluidic fluid is commercially obtainable under the trade name Ferrofluiddics® of ferro fluidics GmbH.

The degree of attenuation that can be achieved with a damping fluid is advantageously independent of the respectively preceding deformation, so that no

"memory" effect arises that would lead to disturbing engraving errors. Over and above this, the degree of damping that can be achieved with a damping fluid can be approximately calculated. A high temperature stability and long-term stability of the degree of damping is also achieved with a damping fluid, since the heat arising as a result of high engraving frequencies can be eliminated well via the damping fluid. The described exemplary embodiment employs a ferrofluidic damping fluid that is held in the damping gap (26) by a magnetic field generated with a magnet, as a result whereof complicated seals can be eliminated. In the exemplary embodiment, an annular retaining magnet (28) for the ferro-fluid is located in an annular channel (29) in the base plate (20) of the damping chamber (18). In order to prevent dust from entering into the damping chamber (18), a seal ring (30) embracing the shaft (6) can be provided, this being located in a recess (31) of the base plate (20).

Fig. 2b shows a section through the damping mechanism (8) in a plane proceeding perpendicular to the axial direction of the shaft (6). The sectional view shows the circularly fashioned damping disk (17).

Fig. 2c again shows a section through the damping mechanism (8) in a plane proceeding perpendicular to the axial direction of the shaft (6). The sectional view shows the fashioning of the circular sector-shaped damping disk (17) as two damping wings.

Fig. 3 shows an exemplary embodiment of a non-rotational-symmetrical damping mechanism (8) having a circular segment-shaped damping disk (17).

Fig. 3a again shows a section through the damping mechanism (8) in axial direction of the shaft (6), whereby the damping disk (17) and the damping chamber (18) are fashioned as circular or, respectively, hollow-cylindrical segments that are not rotationally symmetrical with respect to the axis of the shaft (6). This embodiment can be advantageously employed when an optimally slight distance of the shaft (6) of the engraving element from the generated surface of a printing cylinder is desired. The damping disk (17) is fashioned as circular segment, whereby the edge of the damping disk (17) forming the chord lies as close as possible to the shaft (6). The damping chamber (18) is fashioned as hollow cylinder segment corresponding to the shape of the damping disk (17) fashioned as circular segment.

The fundamental structure of the damping chamber (18) is basically identical to the structure of the damping chamber (18) shown in Fig. 2a.

Fig. 3b shows a section through the damping mechanism (8) in a plane proceeding perpendicular to the axial direction of the shaft (6). The sectional view shows the fashioning of the damping disk (17) as circular segment.

Fig. 4 shows an exemplary embodiment of a rotational-symmetrical damping mechanism (8) having two circular or circular sector-shaped damping disks (17, 17') in a section in axial direction of the shaft (6).

The damping mechanism (8) is basically constructed like the damping mechanism (8) according to Fig. 2a). It differs from the damping mechanism (8) shown in Fig. 2a in that two damping disks (17, 17') arranged parallel to one another and spaced from one another in axial direction of the shaft (6) are connected as double disk to the shaft (6), and in that the damping chamber (18) is divided by an intermediate plate (32) in two sub-chambers (33, 33') for the two damping disks (17, 17'). The intermediate plate (32) is thereby dimensioned such that the two sub-chambers (33, 33') are connected to one another by an additional damping gap (26'). The damping disks (17, 17') are shaped as shown in Fig. 2a or Fig. 2c).

Fig. 5 shows an exemplary embodiment of a non-rotational-symmetrical damping mechanism (8) having two circular segment-shaped damping disks (17, 17') in a sectional view in axial direction of the shaft (6). The damping mechanism (8) is fundamentally constructed as described in Fig. 4. The damping disks (17, 17') are shaped as shown in Fig. 3b.

The damping disk (17) is made, for example, of aluminum or steel. Base plate (20), cover plate (21), spacer ring (22) and intermediate plate (32) are preferably composed of non-magnetic material.

The two damping disks (17, 17') can be supplemented by further damping disks. The employment of more than one damping disk has the advantage that a higher degree of damping is achieved due to the increased damping area that interacts with the damping fluid. Given an identical damping area, the diameter of the individual damping disks can be reduced given employment of a plurality of damping disks. This preferably leads to a lower mass moment of inertia and to lower

circumferential speeds at the edges of the damping disks. This reduces the risk that the damping fluid will modify and deteriorate the damping property.

Fig. 6 shows a development wherein the rotational-symmetrical damping mechanism (8) is structurally combined with the rotational-symmetrically fashioned spoke bearing (9).

Fig. 6a shows a section through the damping mechanism (8) in axial direction of the shaft (6), this agreeing with the sectional view of the damping mechanism (8) shown in Fig. 2a except for the spoke bearing (9). The rotational-symmetrical spoke bearing (9) is composed of an inside ring (35) embracing the shaft (6) and connected thereto, of a stationary outer ring (36) surrounding the shaft (6) and spaced from the inner ring (35), and of a plurality of leaf springs (37) proceeding radially at identical or irregular angular spacings. The broadsides are directed in axial direction of the shaft (6), so that the inner ring (35) is torsionally seated relative to the stationary outer ring (36), namely around the longitudinal axis of the shaft (6). The ends of the leaf springs (37) are respectively clamped in the two rings (35, 36). Outer ring (36) and cover plate (21) of the damping chamber (18) are preferably fabricated as one component part.

Fig. 6b shows a section through the rotational-symmetrical spoke bearing (9) in a plane proceeding perpendicular to the axial direction of the shaft (6).

Fig. 7 shows a development wherein the non-rotational-symmetrical damping mechanism (8) is structurally united with the non-rotationally-symmetrically fashioned spoke bearing (9).

Fig. 7a shows a section through the non-rotational-symmetrical damping mechanism (8) in axial direction of the shaft (6), this coinciding with the section through the damping mechanism (8) shown in Fig. 3a except for the structurally integrated spoke bearing (9). The non-rotational-symmetrical spoke bearing (9) is composed of an inner ring (35) that surrounds the shaft (36) and is connected thereto, of a stationary outer ring segment (36') that surrounds the shaft (6) and is spaced from the inner ring (35'), and of a plurality of radially proceeding leaf springs (37') whose broad sides are likewise directed in axial direction of the shaft (6) and whose ends are respectively secured in the inner ring (35') and in the outer ring segment (36'). Outer

ring segment (36') and circular segment-shaped cover plate (21) of the damping chamber (18) are again a shared component part.

Fig. 7b shows a section through the non-rotational-symmetrical spoke bearing (9) in a plane proceeding perpendicular to the axial direction of the shaft (6).

Fig. 8 shows a perspective view of a rotational-symmetrically fashioned spoke bearing (9).

Fig. 9 shows a perspective view of a non-rotational-symmetrically fashioned spoke bearing (9).